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THE SORA PROJECT READY FOR ITS REALISATION

by

G. RITTER

1966

Joint Nuclear Research Center
Ispra Establishment - Italy

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THE SORA[+] PROJECT READY FOR ITS REALISATION[++]

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G. Ritter

Head of the Joint Nuclear Research Centre, Ispra Establishment - Italy

1) Introduction

In a preliminary communication of December 1964 [1] the author has already given a justification for the study of a periodically pulsed fast reactor at the Research Centre at Ispra. In this communication, we want to report primarily on the progress and the present situation of the development work.

In order to get a detailed elaboration of the construction plans of SORA, a development contract worth $ 150.000,-- was signed about a year ago for a period of one year with the firms "Belgo-Nucléaire" and "Siemens-Schuckert". This development contract is now terminated and led to the final settling of the still open design problems. When drafting the final design of the various parts of the reactor, it became obvious that the problems are not simple but that one can use almost everywhere the so-called "classical design elements". An expensive development of reactor parts, as fuel elements and control rods, could be entirely avoided. Therefore, this development contract has strongly confirmed the reactor design concept as it was proposed by the department for Reactor and Neutron Physics.
A comprehensive description of the design principles of a periodically pulsed fast reactor and of its application in the field of Neutron and Solid State-Physics was given by V. Raievski et al. [2] and W. Kley [3].

+ SORA = Sorgente Rapida, fast source

++ German version published in "Atomwirtschaft" 11 (1966)

Since it is even today not possible to rely only on the rather extended and complex calculations for the design of a new reactor, and this particularly for a periodically pulsed fast reactor, as for instance SORA, already two years ago a critical experiment was planned and designed. Because of lack of financial means this very interesting experiment could not be made at Ispra. Fortunately a very good personal contact exists among our scientists of Ispra and the American scientists of the big National Laboratories of Brookhaven and Oak Ridge, which has finally led to a contract between U.S.A.E.C. and EURATOM to make the critical experiment at the Oak Ridge National Laboratory. In the frame work of this contract, Ispra has built the reactor mock-up of SORA and Oak Ridge National Laboratory has taken the responsability for the provision of the fuel (ca. 55 kg U enriched to 93 % of U^{235}) and the execution of the experimental program. With the kind support of Oak Ridge National Laboratory it was possible that Dr. G. Kistner of Ispra can take a great part in the execution of the experimental program. The execution of this experiment at Ispra would have cost about $ 250.000,--. The preparative work for the critical experiment at Oak Ridge is already finished and the SORA mock-up got critical at Sept. 28 1965. The first preliminary results show already a very good agreement between the experiment and the calculation of the critical mass and the reactivity worth of the piece of Beryllium attached to the pulsing wheel (see fig. 1). With this result one can already show that the reactor concept can be realized without any undue risk for the performance characteristic. The details of the experiment will be of course reported by the Oak Ridge National Laboratory.

In the following only a short description of the characteristic data is given that have been obtained in the course of the development work.

2) The characteristic design data of the SORA-reactor

Fig. 1 shows schematically the reactor parts. The reactor core has a volume of about 5 liters. Highly enriched uranium (ca. 93 % $Uranium^{235}$)

is used in the form of rods, 24 cm long and 1 cm thick. Liquid Metal - a sodium-potassium alloy - is used as coolant. The reactor core is surrounded largely by a 30 cm thick steel reflector. In this reflector there are holes for the H_2O and Zr H_2 moderators. The H_2O-moderator will be cooled down to temperatures of -200 °C and -250 °C and the ZrH_2-moderator will be kept at temperatures of +400 °C. With that so-called hot and cold neutrons can be produced with very high intensity. A wheel, similar to a propeller, with a diameter of 180 cm, turns with a speed of 3000 R.P.M. in front of the reactor core. A 7 cm thick, 11 cm wide and 24 cm high piece of Beryllium is fixed to one of the arms of the propeller, which at each passage reflects the neutrons back into the core, and in this manner the reactor is made prompt critical for a short time (ca. 80 x 10^{-6} sec) and its power is raised to a level up to 250 and 300 MWatt. Between successive pulses the power drops to 0,2 MWatt. During the peak power a thermal flux of 4 x 10^{15} n/cm^2 sec is generated in the moderators.

In Tab. 1, the most important SORA-data are given.

Table 1

1. Average Power	:	P = 1 MWatt
2. Peak Power	:	Pmax = 250 - 300 MWatt
3. Pulse Frequency	:	f = 50 sec^{-1}
4. Pulse Length	:	50 x 10^{-6} sec
5. Max. thermal flux at the surface of the moderator	:	4 x 10^{15} n/cm^{2}sec
6. Leakage neutrons from the core	:	4 x 10^{16} n/sec

Fig. 2 shows a horizontal cross section of the reactor, how it could be built after the existing plans. Fig. 3 is a photograph of a reactor model. As it can be seen from the reactor model, there will be very long evacuated tubes in use with the reactor. These are the so-called neutron guide tubes, as developed in Munich by H. Maier-Leibnitz and P. Springer [4]. Without intensity loss, neutrons can be guided by total reflection over large distances. These neutron guide tubes are of particular importance for the use of pulsed reactors, since one can achieve a high precision in the energy determination of the neutrons by the time of flight, if only very long flight pathes can be used. But this is the case, if neutron guide tubes are used. Fig. 4, Fig. 5 and 6 show the reactor mock-up. It is a geometrically exact simulation of the reactor. The moderators in the steel reflector are simulated by plastic material. The diameter of these moderators is 14 cm. For this zero-power-experiment the wheel consists only of one arm.

3) Planning for construction and financing

The development study was finished so far that also an exact planning for the financing could be elaborated. The comprehensive plan for construction and financing is given in Fig. 7. According to this, the reactor can be built in 35 months, provided that for administrative reasons it is possible to order the steel already 4 months before the actual start of the work. In this plan the costs for the experimental equipment are not included. They will amount to about $ 2 Mill., so that the total costs of the SORA Project will be $ 10 Mill. If the member countries of Euratom would decide the construction of SORA in 1966, the reactor could be taken in operation, according to the present planning, in 1969.

4) Conclusion

The SORA-Project has reached a state that demands a basic decision about its realisation. More development work was done than it is normally the case for the preparation and planning of scientific instruments. The existence of such an intense neutron source as SORA will be of greatest importance for the European physicists, particularly since at Brookhaven (U.S.A.) the first very high flux reactor has become critical. The American physicists will have at their disposal a neutron source that has about 10 to 15 times more neutron flux than most of the European reactors. What this means for the development of neutron physics in Europe does not have to be explained in further detail. Since the SORA-Project could be realized in at least three years, the gap to the American development would not become too big. Furthermore, the periodically pulsed fast reactors are now in a developing state, which means that their power can be increased considerably. For this reason the American physicists have decided to study a pulsed reactor of the SORA-type, however with a power 15 times larger than SORA. This trend is a nice recognition of the research work at Ispra.

The construction of the SORA reactor at Ispra would give a positive outlook to the physicists for a continuous development of their work at the C.C.R. Ispra and would form a seed for the organic development of basic research. This is of utmost importance, since up to now at Ispra emphasis was put on the pure technological development. A support of the SORA-Project could balance the problems in the structure of the present organisation. As already mentioned, the short period for the construction of SORA would reduce the gap to the American development and partly already create competitive conditions for some fields in neutron physics. However, we want to point out that SORA cannot replace a Very High Flux Reactor, since a pulsed fast reactor can only take over a part of the work at a V.H.F.R., this, however, in a very economic manner, which means that for a great number of experiments the costs per neutron will be much lower than at a V.H.F.R. A detailed analysis of the various experiments and conditions can be found with H. Maier-Leibnitz [5]. According to our apprehension, a pulsed fast reactor of the SORA-type is a new development with many possibilities in the near future, which is at least in certain specialized fields superior to the present or even planned neutron sources, as for instance the big linear electron accelerators (average power 200 kWatt) or a very high flux reactor. In a classification of the neutron sources one would find SORA between a very high flux reactor and the big linear electron accelerators, because it produces in the average about 100 times more leak neutrons than a linear accelerator and generates 50 times a second for a time of 50×10^{-6} sec the corresponding neutron flux to a very high flux reactor. With that the SORA-Project presents itself as a very interesting development that justifies any time the technical and financial expenditure for its realisation.

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3. W. Kley, EUR 2538 (1965)

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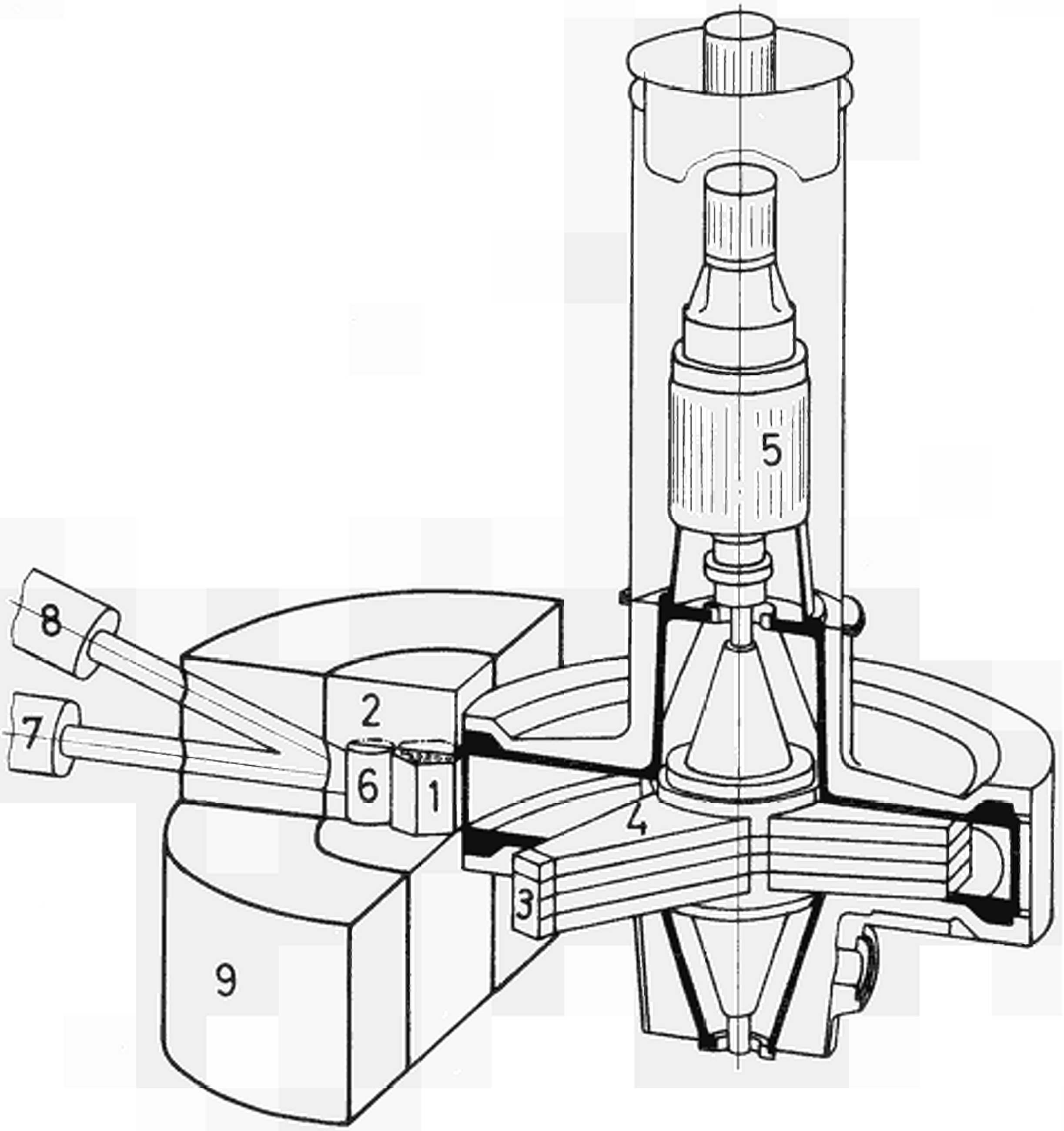
Fig. 1. Schematic Drawing of the SORA Reactor

1. Reactor-Core
2. Steel-Reflector
3. Beryllium-Reflector
4. Propeller
5. Propeller-Driving motor
6. Cold Neutron Source (T -200°C)
7. Horizontal Beam tubes
8. Inclined Beam Tubes
9. Reflector



SORA - SCHEME

Fig. 2. Horizontal Cross Section of the Reactor

1. Reactor-Core
2. Upper Reflector
3. Fuel Element Assembly Support Plates
4. Reactor Vessel
5. Pulsation Device
6. Moving Reflector
7. Stationary Reflector
8. Lower Stationary Reflector
9. Scatterer Loading Tube
10. Beam Channel
11. Thermal Shield
12. Biological Shield
13. Beamport Slot
14. Beam Tube Shutter
15. Vertical Irradiation Tube
16. Control Rod
17. Pulsation Cell
18. Lead Shutter
19. Handling Channels
20. Pulsation Cell Plug
21. Compensation Block
22. Moderator Block
23. Tight Beam-channel Insert
24. Beam Port Block
25. Rails
26. Pulsation Device Fixation and Adjustment
27. Installation Duct
28. Installation Gallery
29. Duct for primary NaK-Loop
30. Duct for auxiliary Cooling

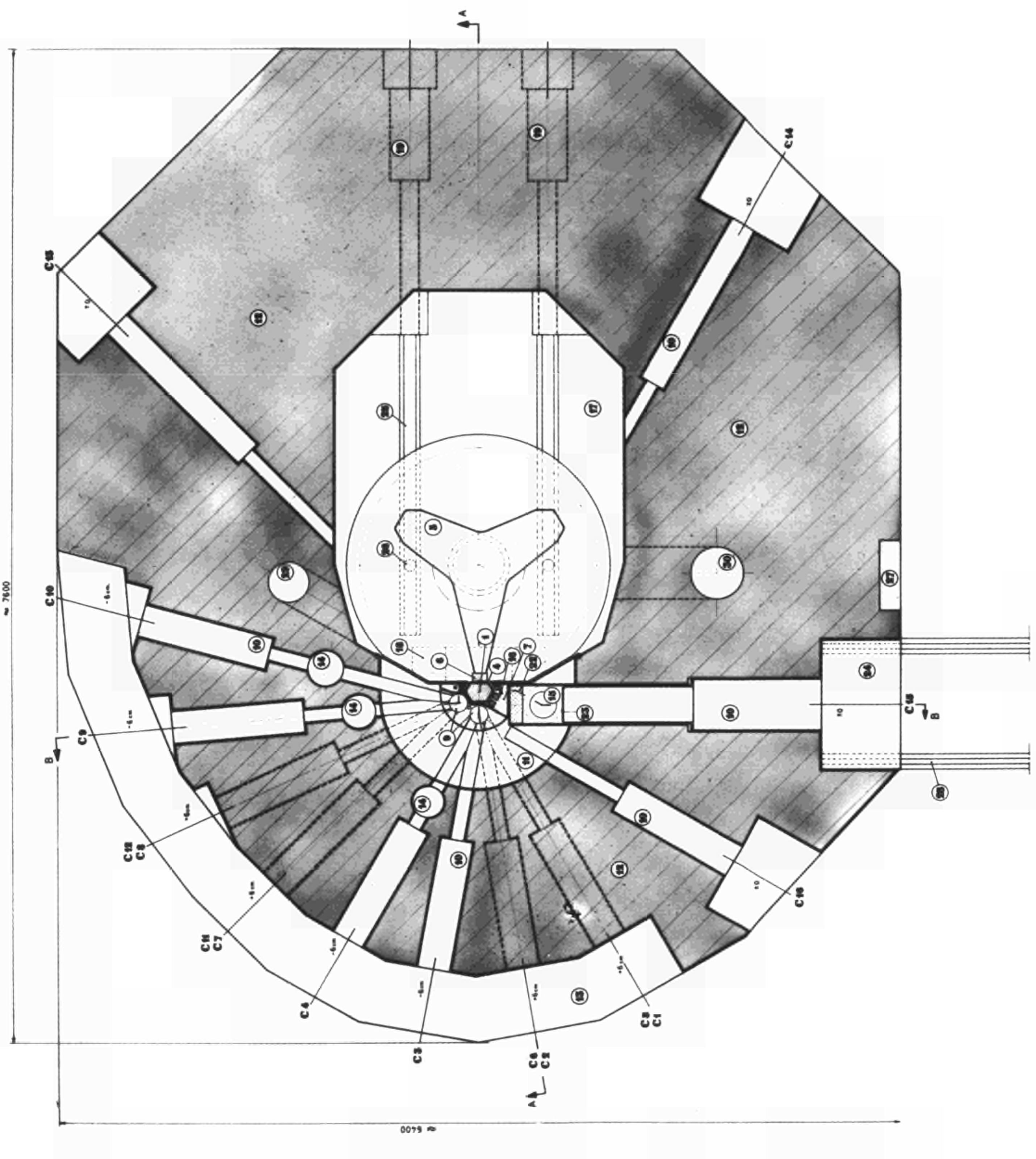


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Fig. 3. SORA-Reactor-Model, seen from North-East

1. Reactor Building
2. Operation-Building
3. Additional Technical Buildings
4. Beam Tubes
5. Team Tube (1 km)

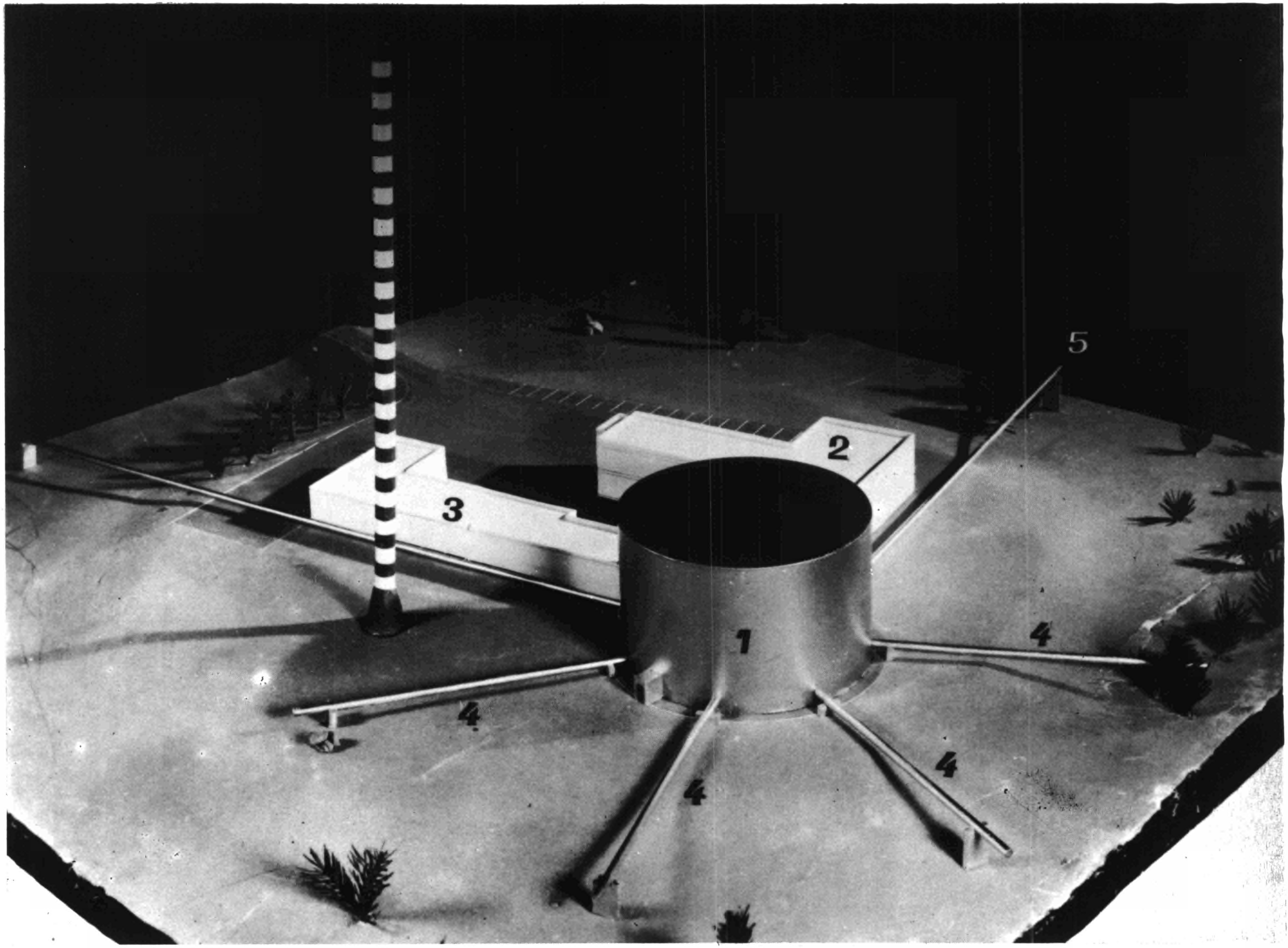

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Fig. 4. SORA-Reactor-Mock-up

1. Cold Neutron Source, simulated by plastic material
2. Thermal Neutron Source, simulated by plastic material
3. Reactor core without Fuel Elements
4. Control Rods
5. Steel Reflector
6. Openings for the Beam Channel

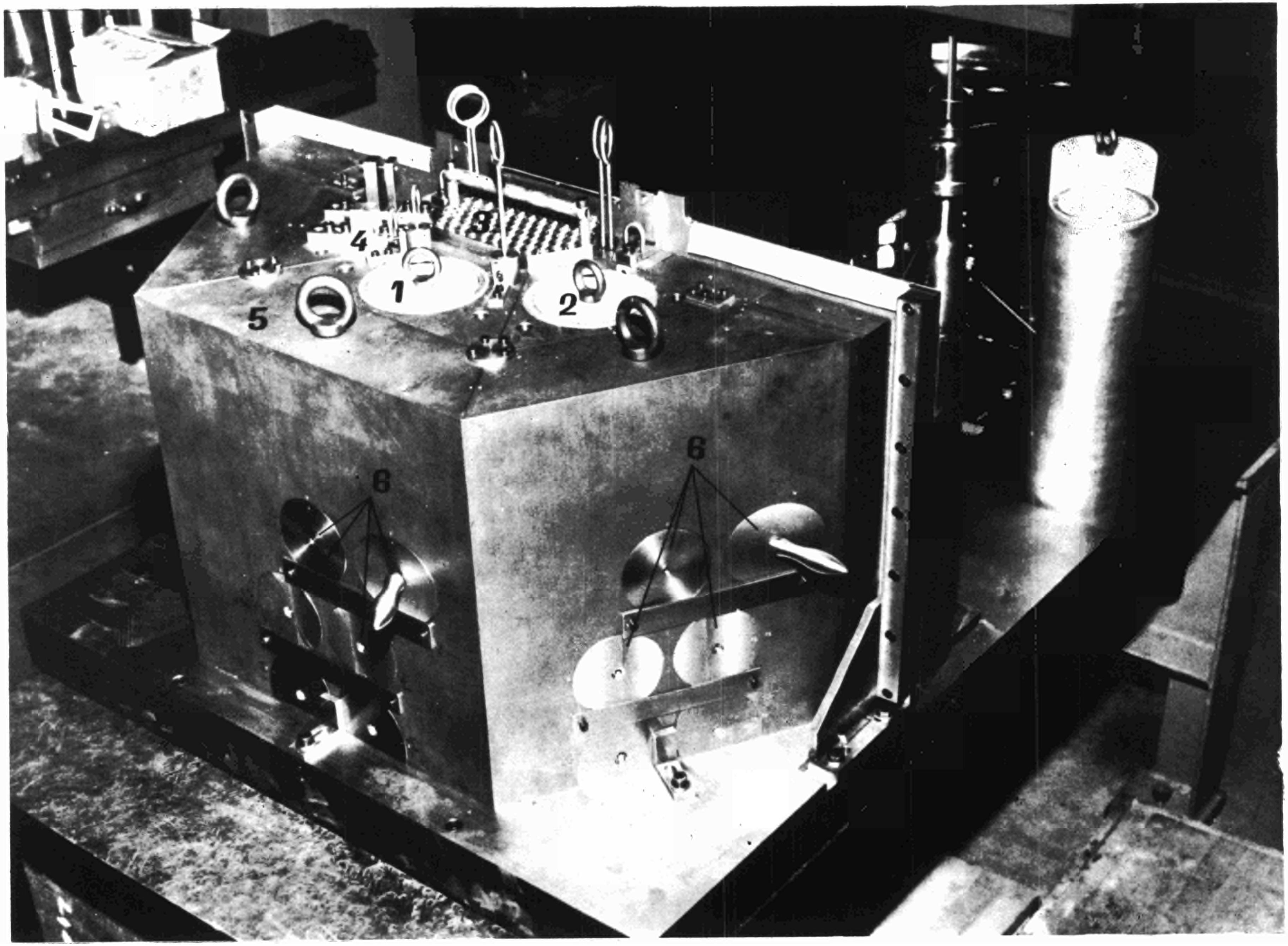
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Fig. 5. SORA-Reactor-Mock-up

1. Cold Neutron Source
2. Thermal Neutron Source
3. Core
4. Control-Rods
5. Steel Reflector

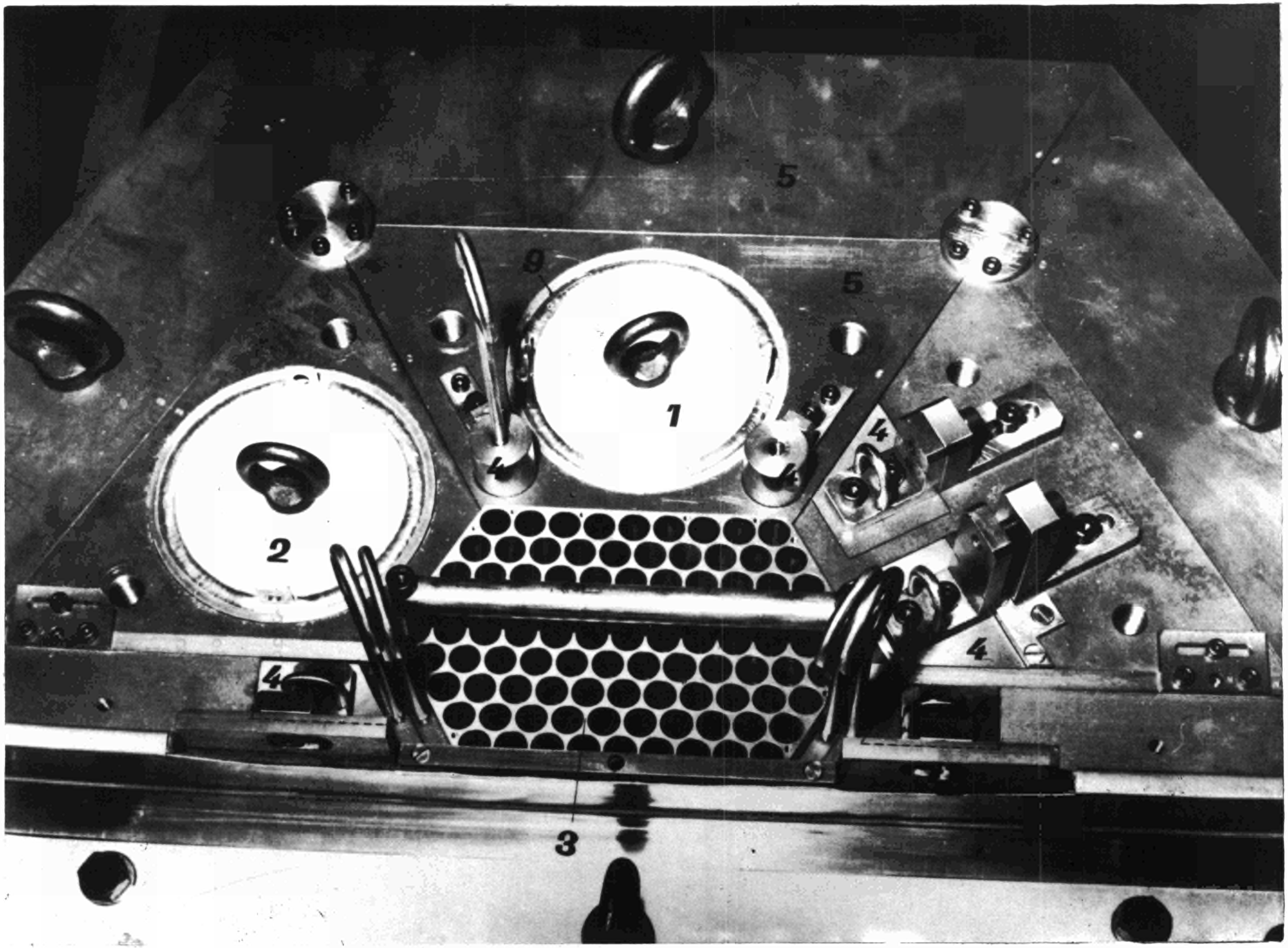
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Fig. 6. SORA-Reactor-Mock-up

1. Plastic Material for the Simulation of the Cold Neutron Source
9. B_4C-Absorber, it prevents the return of thermal neutrons into the core
7. Beryllium Reflector [7 x 11 x 24 cm] fixed to the movable Propeller Section (Radius 90 cm)
8. Propeller Section that simulates the pulsation device

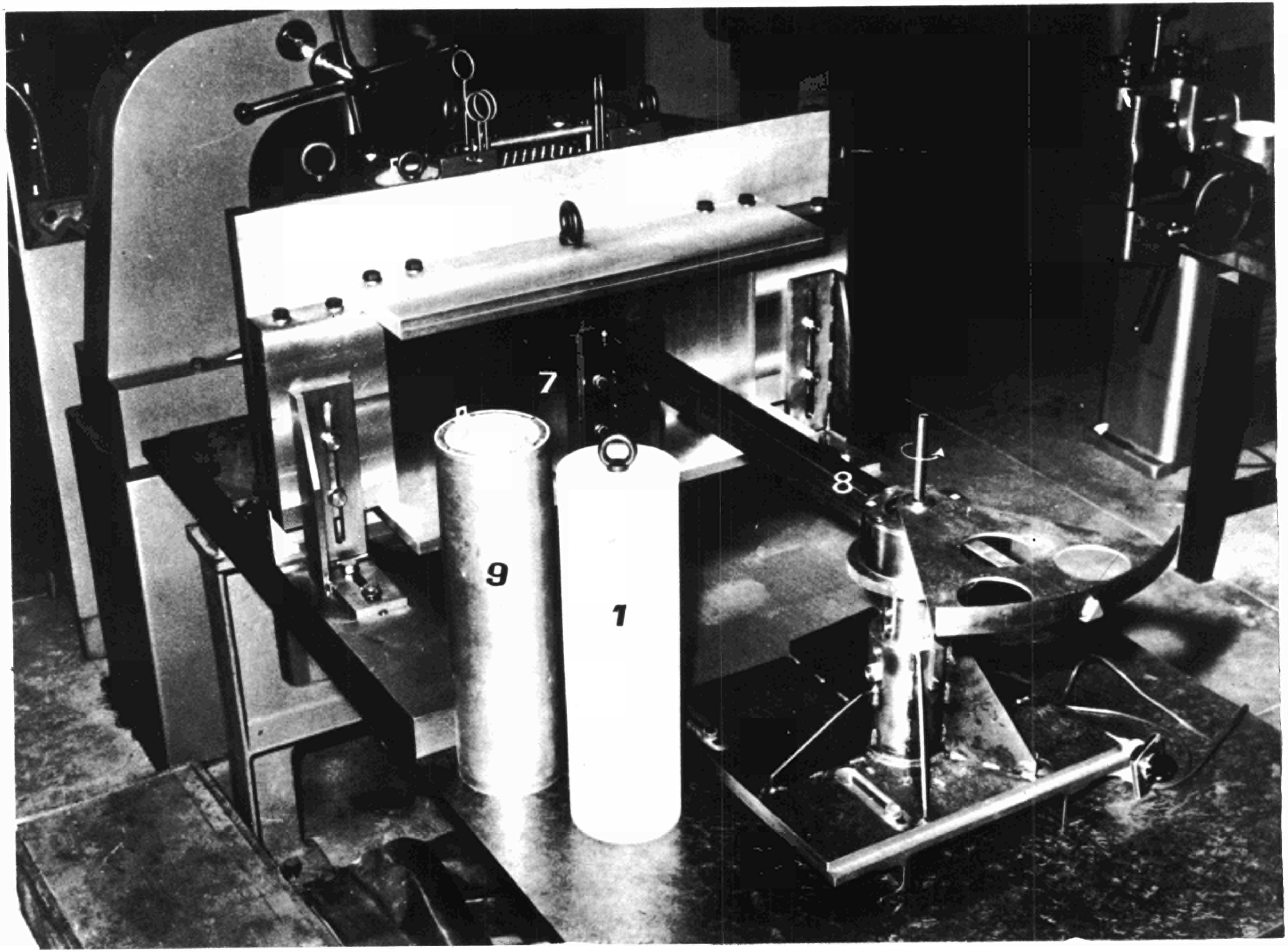
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Fig. 7. Planning for Construction and Financing

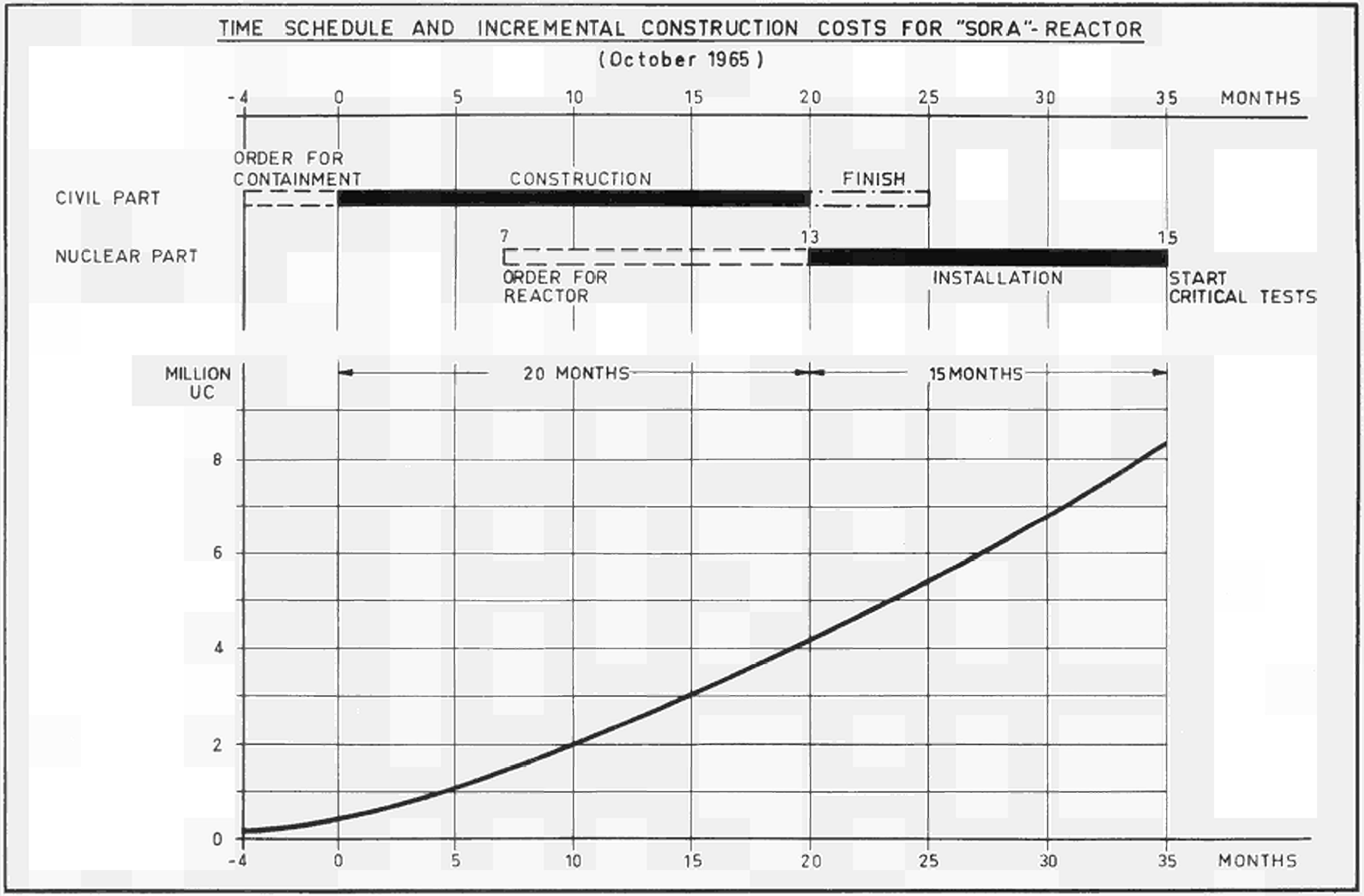
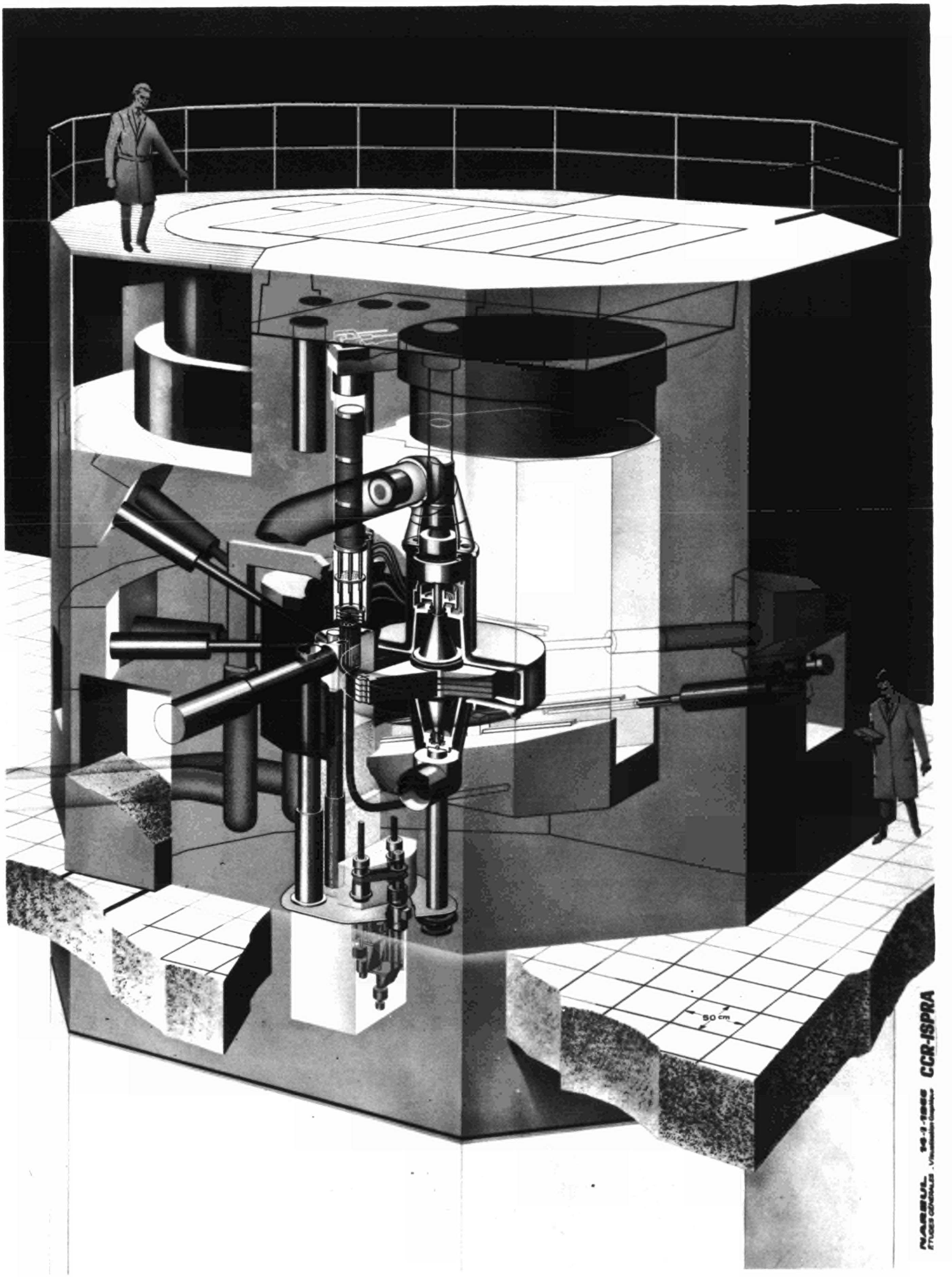


Fig. 8. Perspective Cross Section of the Reactor



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Alfred Nobel

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